Boeing DSOA

Technical Memorandum

Use of Mechanical Dredging and Hydraulic Transport for Removal of Early Removal Areas

Introduction

This Tech Memo presents methodology for use of mechanical dredging combined with hydraulic transport for removal of two small Early Removal Areas (ERA's) of material containing PCB's exceeding 50 PPM.

These two ERA's are located offshore of the Southwest Bank area within the Duwamish DSOA (See Figure 1). One is located beneath temporary outfall Z and the second to the south of temporary outfall Z. The ERA located under temporary outfall Z will require removal of a portion of temporary outfall Z including a section of outfall pipe and possibly two piling to perform the dredging. Temporary outfall Z was installed at the start of the project to prevent sediment erosion during the project by diverting storm water offshore that previously discharged near the bank. Removal of temporary outfall Z will be coordinated with predicted precipitation targeting period of predicted low precipitation. During the time temporary outfall Z is out of service storm water will be redirected to other existing outfalls.

The combined volume of the two ERA's, including excavation to achieve stable slopes is approximately 300 cubic yards. The location of the two ERA's along with DRWS components discussed in this memo are shown on the attached Figure 1.

Removal and Transport Method

ERA sediments will be mechanically dredged using the instrumented PC800 dredge with Young manufacturing clamshell bucket, same as is currently being used for the other open access dredging. ERA sediments would be dredged following all project permits, requirements and BMP's.

ERA Sediments will be dredged based upon the revised dredge plan, developed using the 25 PPM contour line and a 2.5 foot removal depth below existing mudline. The 25 PPM contour was developed based on available sediment data. By using the 25 PPM contour line as the required removal limit the removal and proper disposal of all material at or above 50 PPM can be performed with high degree of certainty.

Dredging will be performed using standard project practices for precision dredging including project BMP's developed to reduce resuspension, release and residuals. Dredged ERA material will be placed into a water tight sediment barge. On average, during typical project dredging, each bucket placed into the barge is approximately 50% saturated sediment and 50% free water. DSOA project documents require that this water placed into the sediment barge be pumped off to the onsite Dredge Return Water System (DRWS). During typical DSOA dredging, this water along with some sediment is pumped off continuously during dredging. Based on CS2 data (See memo, Attachment 1), the Dredge Water pumped from the barge to the tri-flo typically contains on the order of 5% to 11 % solids. Once the barge is full and free water removed, the sediments are then offloaded mechanically by clamshell bucket at the LaFarge facility.

The proposed change for dredging of the ERA's is to increase the percentage of solids pumped from the barge to the DRWS by mixing the water that is placed into the barge during the normal dredging practice with the dredged sediment to produce a pump-able slurry, allowing the sediments to be offloaded by pumping to the DRWS. Additional water will be added to sediment as necessary using the dredge bucket or a small pump. The dredge bucket will then be used to gently mix the sediment to create the desired slurry consistency for pumping to the DRWS. The slurry will then be pumped to the DRWS for solids removal. The overall slurry produced will be well within the handling capacity of the DRWS in terms of both flow rate and solids content. Pumping rates (flow rates) will be similar to normal barge dewatering rates, typically within the range of 600 to 1000 GPM. It is anticipated that slurry to be pumped from barge would be approximately 15% solids, a minimal increase from typical barge pump off concentrations of 5% to 11% solids.

DRWS Solids Removal, Stabilization and Disposal

Prior to handling of ERA sediments the sediment discharge area in front of the Tri-Flo unit and the primary settling areas within the settling basin, defined as the area before the two weirs, will be cleaned of bulk sediments using a long reach excavator. DRWS data from CS2 is presented in attached memo on DRWS performance (Attachment 1).

Each of the two weirs is approximately 8" high; water depth above the weirs can range from 1.5' to near 0 as operations draw down the basin. The first weir is approximately 150' from the head of the basin, the second weir would be installed approximately 100' beyond the first weir. As noted in the attached memo, little carryover of sediments beyond the first weir was observed during CS2.

Same as during normal operations, slurry pumped from the sediment barge will first enter the Tri-Flo unit for separation of coarser material. Based on installed screens and data from CS2, it is anticipated that the Tri-Flo will remove material coarser than a #100 sieve. Coarse materials removed by the Tri-Flo will be collected, stabilized and containerized or loaded into leak proof trucks for disposal at approved subtitle C facility. Based on available sediment grainsize data (See Attachment 2), approximately 68% of material is expected to pass the # 100 sieve, resulting in roughly 32% or approximately 100 CY of the 300 CY to be dredged would be removed from the slurry by the Tri-Flo unit. Slurry exiting the Tri-Flo will then enter north-east corner of settling basin, as shown on Figure 1.

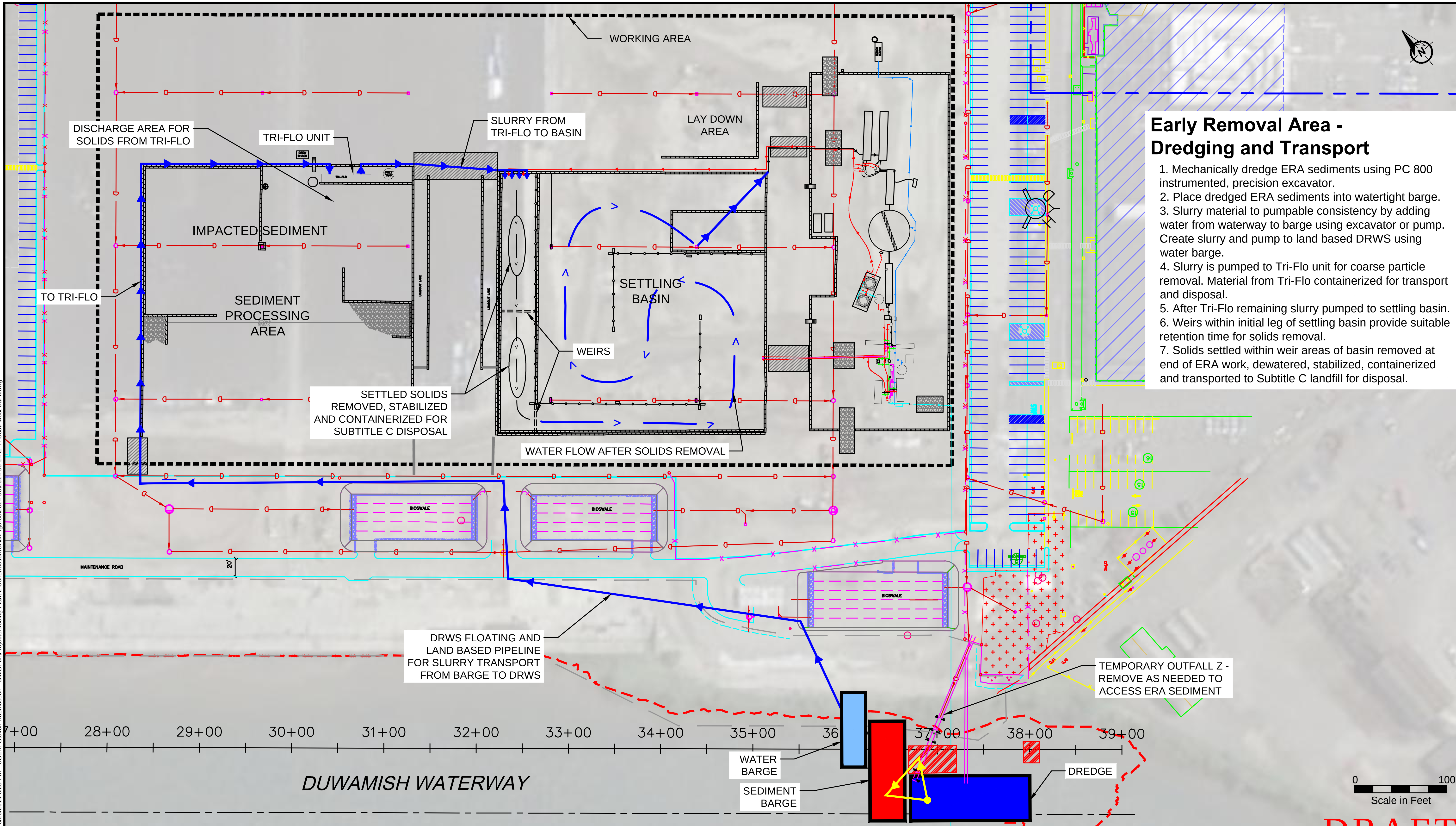
Based on data from CS2, presented in Attachment 1, it is anticipated that over 99% of the sediment entering the settling basin will settle out before the weirs and that approximately 0.2% of material entering basin will reach the EC units. This includes both material discharged to the basin directly from the Tri-Flo as well as coagulated sediment produced in the DRWS and collected in clarifier and cone tank prior to discharge back to northeast corner of basin for settling (coagulated sediments that passed thru basin previously are now large enough to settle out in area before weir).

Solids that settle within basin are then removed using long reach excavator. Removed solids are loaded into sealed truck for transport to adjacent Sediment Processing Area (SPA), located just north of the settling basin (See Figure 1). Sediments are then placed in SPA and stabilized to meet no free liquid criteria (based on visual inspection) using Zap-Zorb or other suitable material, then loaded into containers or trucks and transported to approved subtitle C facility for disposal. It is anticipated that trucks would be used for the majority of the material. Any debris or materials larger than the pumps capacity will remain on the barge and be mechanically offloaded. Depending upon nature and quantity of debris it will be containerized (metal container or large lined supersack) and then offloaded directly to Boeing property at Slip 6 or other suitable offload location such as LaFarge.

Schedule

It is anticipated that dredging and hydraulic transport of material to DRWS will take on the order of 1 to 3 days, depending upon debris encountered, tides, tribal fishing and other factors. Prior to start of ERA dredging, non-ERA sediments will be removed from cone tanks, settling basin area upstream of weirs and from SPA area to be used for ERA materials. ERA dredging will then be performed. At completion of ERA dredging and hydraulic transport, ERA sediments will be removed from cone tanks, settling basin area upstream of weirs and from SPA area used for ERA materials. Sediments will then be stabilized to meet no visible free liquid criteria, loaded into appropriate trucks or containers and then shipped offsite for disposal at approved subtitle C facility.

Figures



Early Removal Area - Dredging and Transport

1. Mechanically dredge ERA sediments using PC 800 instrumented, precision excavator.
2. Place dredged ERA sediments into watertight barge.
3. Slurry material to pumpable consistency by adding water from waterway to barge using excavator or pump. Create slurry and pump to land based DRWS using water barge.
4. Slurry is pumped to Tri-Flo unit for coarse particle removal. Material from Tri-Flo containerized for transport and disposal.
5. After Tri-Flo remaining slurry pumped to settling basin.
6. Weirs within initial leg of settling basin provide suitable retention time for solids removal.
7. Solids settled within weir areas of basin removed at end of ERA work, dewatered, stabilized, containerized and transported to Subtitle C landfill for disposal.

LEGEND

DSOA Boundary	UPLAND WORKING AREA BOUNDARY - ALL STORM AND DREDGE WATER INSIDE BOUNDARY COLLECTED AND PROCESSED IN DRWS
ERA (TSCA over 50 PPM) Areas	

THE BOEING COMPANY
SEATTLE, WASHINGTON

BOEING PLANT 2
DUWAMISH WATERWAY SEDIMENT REMEDIATION

ERA - DREDGING AND UPLAND TRANSPORT

DOF DALTON OLMSTED FUGLEVAND

FIGURE 1

SEPTEMBER 26, 2014

Attachment 1 – Hydraulics Memo

Memo

To:	Dave Bartus, EPA Melissa Blankenship, EPA Rob Webb, DOF	Project:	0131320090.DRWS
From:	Patrick Hsieh, AMEC	cc:	Project File
Tel:	(206) 342-1773		
Fax:	(206) 342-1761		
Date:	October 1, 2014		

Subject: **Hydraulic Settling Analysis for the Dredge Return Water System**
Boeing Plant 2
Seattle, Washington

Data were collected during Construction Season 2 (CS2) to assess where solids were being collected and removed throughout the dredge return water system (DRWS) and the size distribution of those solids. This memo summarizes operational observations and describes methods for dredge solids handling during Construction Season 3 (CS3). This memo also includes results of grain size analyses for sediment samples taken at the TRI-FLO and settling basin during CS2.

CS2 OPERATIONS SUMMARY

The overall DRWS system flow diagram is depicted in Figure 1, and the system layout is shown in Figure 2. Dredge return water was pumped at rates ranging from 600 to 1,000 gallons per minute (gpm) from the sediment barges to a TRI-FLO screen unit to remove debris, gravel, and sand. The material pumped from the sediment barges was typically 5 to 11 % solids. The water from the TRI-FLO was then pumped to the northeast corner of the settling basin (Figure 2). A floating silt curtain and Ecology blocks were utilized to direct the flow of water with suspended solids in a serpentine pattern around the settling basin to encourage settling of solids. The first two legs parallel the north and the west walls of the basin (Figure 2). An existing approximately 8-inch-tall weir is located approximately 150 feet from the head of the basin.

Retention times to the weir varied from a minimum of 30 minutes to 135 minutes, depending on flow rates and depth of water in the basin. Retention times are rough estimates, as some amount of water was able to seep directly through the silt curtain. During normal operations, the depth of the water in the basin generally ranged from 1 to 1.5 feet, resulting in a retention time range of 45 to 70 minutes in the area upstream of the weir. In addition, sediment depth ranged from a few inches to over a foot. The water was generally observed to flow predominantly along the serpentine flow path. No measurable amount of suspended solids was observed to pass through the silt curtains in the settling basin. No significant amount of solids settling occurred past the weir under the various sediment depth, basin depth, and TRI-FLO pumping rates during CS2.

After winding through the settling basin, water at the southeast corner of the settling basin contained only limited quantity of very fine suspended silts and clays. From the southeast corner of the settling basin, the water was pumped to the electrocoagulation units (ranging from approximately 200 to 800 gpm), the defoam tank, the clarifier, and finally through the polish step (sand filters, bag filters, and granular activated carbon [GAC] filters).

AMEC Environment & Infrastructure, Inc.
600 University Street, Suite 600
Seattle, Washington
USA 98101-4107
Tel (206) 342-1760
Fax (206) 342-1761
www.amec.com

Solids from the DRWS during CS2 accumulated at three locations within the treatment system: the TRI-FLO, the first leg of the settling basin (along the north wall), and the cone tanks. Greater than 99% of the solids pumped to the DRWS were removed at the TRI-FLO and the first leg of the settling basin (Table 1) with less than 1% of the solids making it to the cone tanks.

A grain size analysis was performed in February 2014 to assess TRI-FLO performance and settling basin performance. Table 2 provides the results of the detailed grain size analysis (% passing). Figure 2 depicts settling basin sampling locations. Generally, the size of particulates passing corresponds to the screen sizes in the TRI-FLO unit. The TRI-FLO unit typically removed nearly all of the material coarser than the #100 sieve. The majority of materials between a #100 sieve and a #200 sieve, plus any material that managed to pass the TRI-FLO, typically settled out in the area before the weir. By 120 feet from the head of the basin, the majority of the solids consisted of very fine particulates, with grain sizes of less than 75 microns. Typically only materials finer than the #200 sieve made it past the weir and into the DRWS, where they were then collected in the cone tanks after coagulation. However, cone tank material is then discharged back into the head of the basin for settling and collection as described below.

The solids collected from the TRI-FLO during CS2 were generally dry enough to be stackable and usually did not require stabilization to pass the paint filter test. These TRI-FLO solids were temporarily stockpiled in the Sediment Processing Area (SPA) until enough sediment was accumulated for off-site disposal by truck (Figure 1).

Solids from the settling basin were collected by long-reach excavator, gently loaded into a sealed dump truck (filled to less than half full), and dumped into the SPA area for stabilization for off-site disposal by truck. The majority of the solids in the settling basin were observed to drop out of suspension within 120 feet from the northeast corner in the first segment of the settling basin that parallels the north wall. Only a few inches of solids accumulated at 180 feet from the northeast corner, with a slight dusting of sediment occurring past the northwest corner (in the channel along the west wall).

The suspended fines that made it through to the electrocoagulation units were coagulated to form a floc in the defoam tanks. This floc then settled in the clarifier. Grab samples of the slurry from the clarifier indicated that the slurry was typically about 1% solids during CS2. This slurry was then pumped from the clarifier to the cone tanks, where the slurry was allowed to dewater until it contained approximately 10% solids. This thickened slurry was then pumped back to the head of the settling basin and was collected by long-reach excavator. Decant water from the cone tanks was pumped to the southwest corner of the settling basin.

Backwash from the sand filters and GAC filters, which contains fine particulate, was directed back into the settling basin at the southwest corner. In addition, treated water (with iron floc) from the initial electrocoagulation unit plate was directed to the southwest corner of the settling basin. Finally, treated DRWS water that failed to pass turbidity or pH tests was also directed back to the settling basin in the southwest corner. The amount of total solids resulting from these steps was minimal, resulting in only a dusting of sediment along the southern half of the settling basin. No solids from the southern half of the settling basin were collected during CS2.

CS3 SOLIDS REMOVAL PLANNING

Minimal changes have been made to the DRWS for CS3 operations. Most changes were made to make the system more robust, rather than to change any overall processes.

- Pump impellers, housings, valves, and screens were replaced on the TRI-FLO unit as necessary to improve performance and reliability during CS3.
- Additional ecology blocks were added to the settling basin so that sediment stayed in the north channel and avoid short circuiting. During CS2, the silt curtain was observed to be unstable when several feet of solids had built up in the first 120 feet of the basin. As a result, the silt curtain was temporarily bypassed where breaches occurred. A replacement silt curtain was installed during CS2 as necessary to repair the breaches. However, prior to CS3, a double-high row of ecology blocks was extended approximately 200 feet from the northeast corner to prevent similar breaches from occurring during CS3.
- Minor improvements to the clarifier and defoam tank aeration systems were made to improve solids settling.

DREDGING OF EARLY REMOVAL AREAS (ERA'S)

During CS3, the early removal areas (sediment containing greater than 50 parts per million [ppm] polychlorinated biphenyls [PCBs]) will be mechanically dredged and placed on a sediment barge. Approximately 300 cubic yards total of early removal materials will be dredged over a period of 1-2 days.

During dredging of the early removal materials, water will be added to bring the total solids content to approximately 15 percent solids, and this sediment slurry will be pumped to the TRI-FLO. Flow rates will be in the range of 600 to 1,000 gpm, similar to normal dredging dewatering. The majority of the additional solids are expected to be in the coarse fraction (sands and gravels) that will be removed by the TRI-FLO unit. Minimal extra loading is expected for the settling basin and flow rates will be within the normal range of operations from CS2.

The TRI-FLO and settling basin will have bulk sediments removed prior to dredging the early removal materials. Solids will be handled as standard non-hazardous soils and sent for offsite disposal, as in CS2. In addition, a number of minor modifications to the DRWS will be implemented prior to the dredging of the early removal materials.

A second 8-inch weir will be added to the northwest corner of the settling basin (Figure 2). This additional weir will provide almost double the retention time for solids settling in the north channel of the settling basin (approximately 90 to 130 minutes).

Early removal solids from the TRI-FLO and the north channel of the settling basin will be collected in the SPA (as under normal DRWS operations), stabilized if necessary, handled as TSCA (>50 ppm PCBs) waste, and disposed of off-site by truck.

Prior to resuming normal DRWS operations, all equipment (TRI-FLO, excavator, dump truck, etc), the north channel of the settling basin, and the SPA areas will have bulk sediments removed, and again these materials will be handled as TSCA (>50 ppm PCBs) waste.

Attachment(s): Table 1 - Dredge Return Water Solids Distribution, February 20, 2014
Table 2 - Grain Size Analysis of DRWS, February 20, 2014
Figure 1 - Water Quality Treatment System Flow Diagram
Figure 2 - Dredge Return Water System Layout

TABLE 1

DREDGE RETURN WATER SYSYTEM SOLIDS DISTRIBUTION

Boeing Plant 2
Seattle, Washington

Source	Typical		Estimated Maximum	
	Dry solids (cubic yards per day)	%	Dry solids (cubic yards per day)	%
TRIFLO	1.7	9.3	7.0	15.4
Settling Basin	16.8	90.4	38.6	84.4
Influent to EC units	0.05	0.3	0.10	0.2
Total	18.6	100.0	45.8	100.0

TABLE 2

GRAIN SIZE ANALYSIS OF DREDGE RETURN WATER SYSTEM, FEBRUARY 20, 2014 [1]

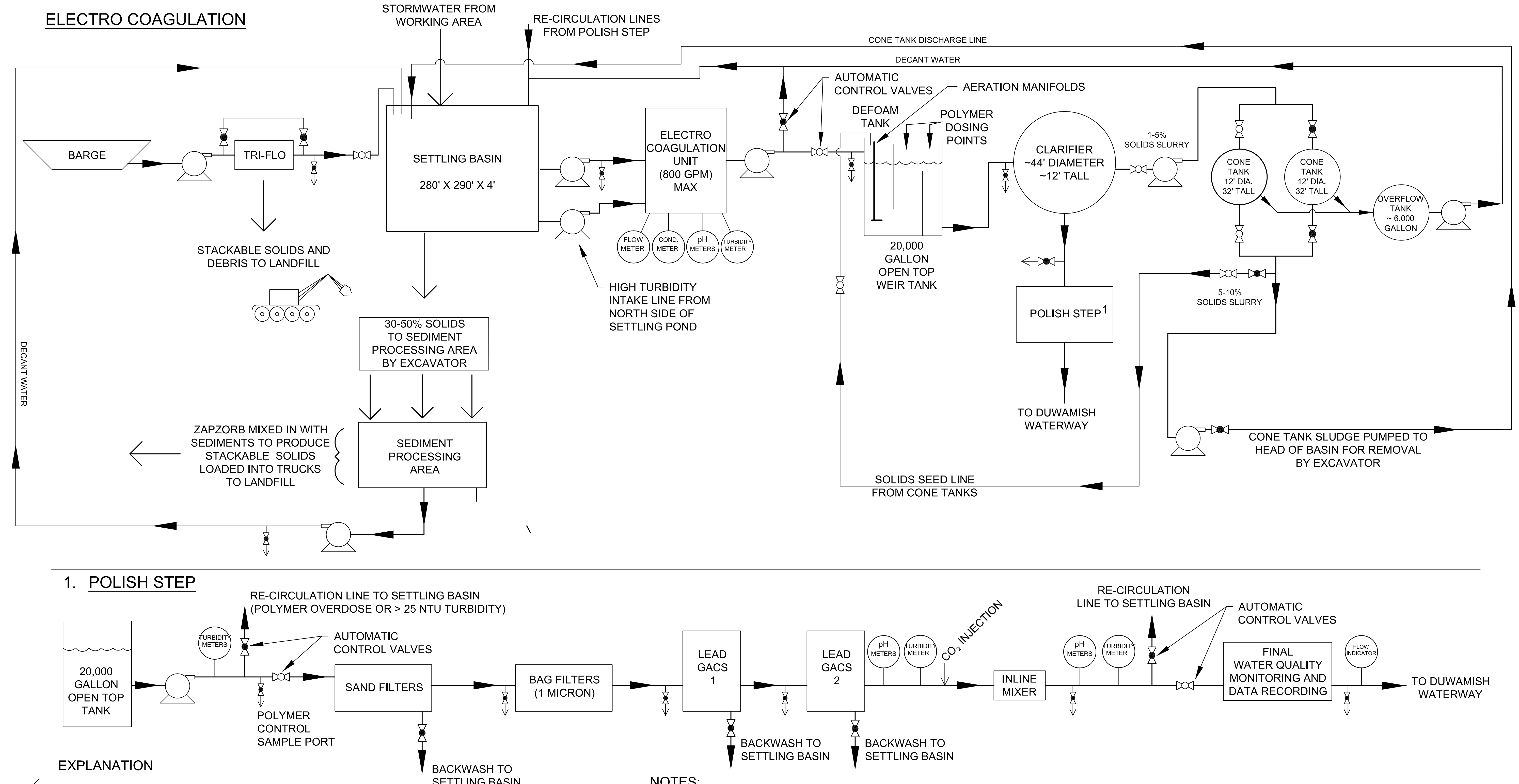
Boeing Plant 2
Seattle, Washington

Sample ID	Description of Sample Location	3"	2"	1 1/2"	1"	3/4"	1/2"	3/8"
		Sieve Size (microns) Percent Passing						
TRIFLO-1-022014	1st shakers (#30 mesh screens) of TRI-FLO	100.0	100.0	100.0	100.0	100.0	100.0	100.0
TRIFLO-2-022014	2nd shakers (#80 mesh screens) of TRI-FLO	100.0	100.0	100.0	100.0	100.0	100.0	100.0
TRIFLO-3-022014	3rd shakers (#120 mesh screens) of TRI-FLO	100.0	100.0	100.0	100.0	100.0	100.0	100.0
BASIN-1-022014	5 Feet from head of basin	100.0	100.0	100.0	100.0	100.0	100.0	100.0
BASIN-2-022014	60 Feet from head of basin	100.0	100.0	100.0	100.0	100.0	100.0	100.0
BASIN-3-022014	120 Feet from head of basin	100.0	100.0	100.0	100.0	100.0	100.0	100.0
BASIN-4-022014	180 Feet from head of basin	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Sample ID	Description of Sample Location	#4 (4750)	#10 (2000)	#20 (850)	#40 (425)	#60 (250)	#100 (150)	#200 (75)
		Sieve Size (microns) Percent Passing						
TRIFLO-1-022014	1st shakers (#30 mesh screens) of TRI-FLO	99.4	94.9	80.1	37.8	17.4	12.6	9.8
TRIFLO-2-022014	2nd shakers (#80 mesh screens) of TRI-FLO	100.0	100.0	99.9	95.8	71.9	50.1	18.2
TRIFLO-3-022014	3rd shakers (#120 mesh screens) of TRI-FLO	100.0	100.0	100.0	99.6	98.9	97.3	86.8
BASIN-1-022014	5 Feet from head of basin	100.0	100.0	99.6	98.6	96.0	92.4	84.1
BASIN-2-022014	60 Feet from head of basin	100.0	100.0	99.7	98.6	96.1	93.3	84.5
BASIN-3-022014	120 Feet from head of basin	100.0	100.0	99.6	99.3	99.1	98.9	98.5
BASIN-4-022014	180 Feet from head of basin	100.0	100.0	99.8	99.5	99.3	99.0	98.3

Sample ID	Description of Sample Location	(32)	(22)	(13)	(9)	(7)	(3.2)	(1.3)
		Sieve Size (microns) Percent Passing						
TRIFLO-1-022014	1st shakers (#30 mesh screens) of TRI-FLO	9.2	8.6	7.6	5.6	4.6	3.1	2.0
TRIFLO-2-022014	2nd shakers (#80 mesh screens) of TRI-FLO	4.1	3.3	2.9	2.9	2.9	2.1	1.6
TRIFLO-3-022014	3rd shakers (#120 mesh screens) of TRI-FLO	28.2	12.1	6.5	4.5	3.5	2.5	2.0
BASIN-1-022014	5 Feet from head of basin	54.2	38.3	27.1	19.9	15.2	8.8	3.2
BASIN-2-022014	60 Feet from head of basin	52.5	35.0	24.7	18.3	13.5	8.0	4.0
BASIN-3-022014	120 Feet from head of basin	78.8	70.3	48.4	37.0	23.7	14.2	6.6
BASIN-4-022014	180 Feet from head of basin	73.8	61.3	47.0	35.5	25.9	12.5	5.7

Note:
1. Samples collected when the settling basis ranged from 1.1 - 0.69 feet as measured at the staff guage.



EXPLANATION

- PROCESS STEP
- PIPE FLOW DIRECTION
- NORMALLY OPEN BALL VALVE
- NORMALLY CLOSED BALL VALVE
- SAMPLE TAP
- PUMP

NOTES:

SETTLING BASIN:
WORKING VOLUME = ~810,000 GALLONS
TOTAL VOLUME = 2,000,000 GALLONS

CLARIFIER:
WORKING VOLUME = 83,000 GALLONS
TOTAL VOLUME = 132,000 GALLONS

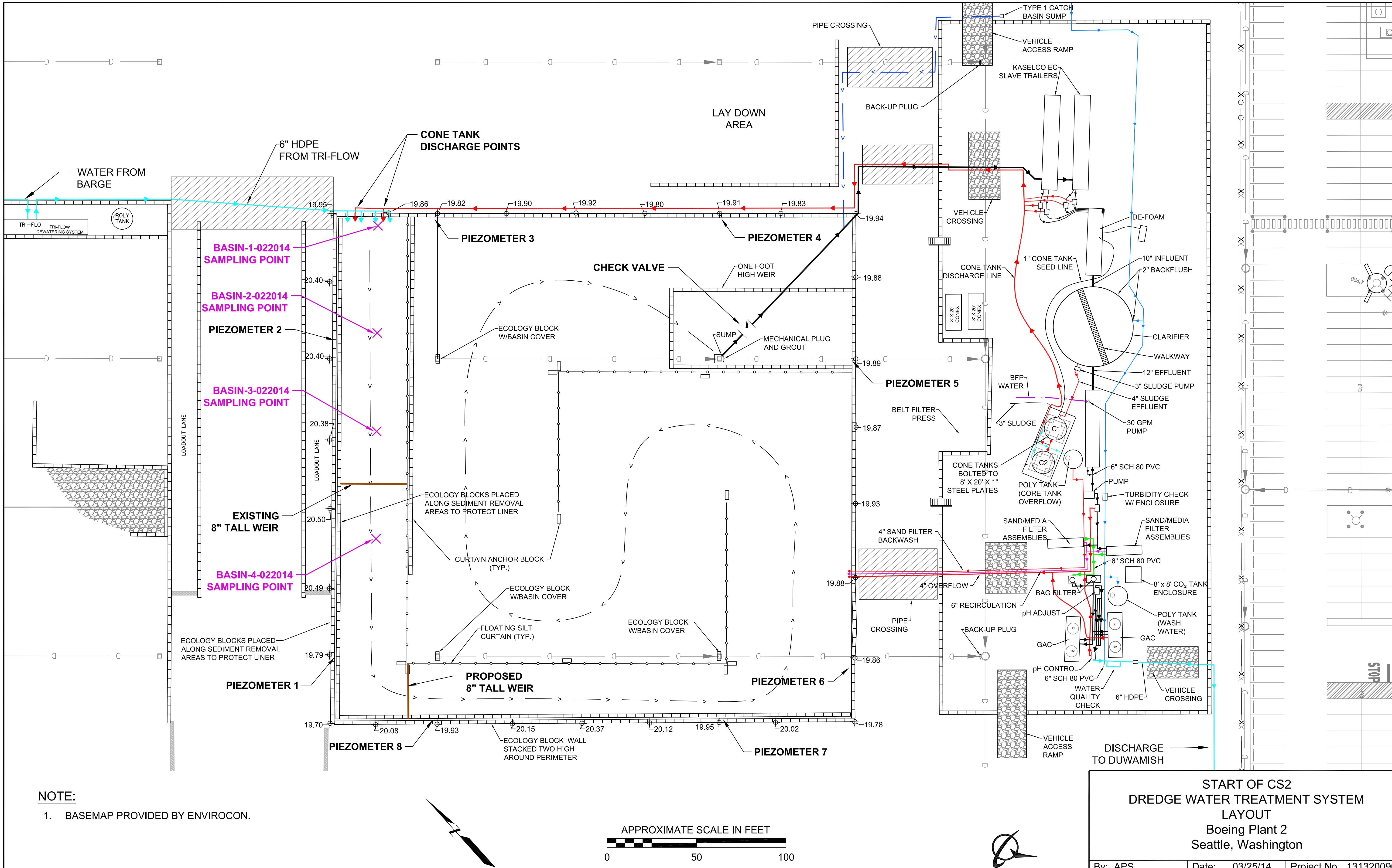
CONE TANK (2):
WORKING VOLUME = 27,000 GALLONS EACH
TOTAL VOLUME = 27,000 GALLONS EACH

TURBIDITY AND pH METERS:
ALL pH SENSING LOCATIONS HAVE TWO METERS TO ENSURE THE REDUNDANT MEASUREMENT FOR ALL AUTOMATIC CONTROL FEATURES. TURBIDITY METERS AT START AND END OF SYSTEM ARE SINGLE, REDUNDANT METERS ARE USED AT THE START OF THE POLISH STEP.

COND. = CONDUCTIVITY

BOEING

END OF CS2 WATER QUALITY TREATMENT SYSTEM FLOW DIAGRAM Boeing Plant 2 Seattle, Washington		
By: APS	Date: 03/28/14	Project No. 13132
		Figure 1



NOTE:

1. BASEMAP PROVIDED BY ENVIROCON.

START OF CS2
DREDGE WATER TREATMENT SYSTEM
LAYOUT
Boeing Plant 2
Seattle, Washington

By: APS	Date: 03/25/14	Project No. 131320090
		Figure 2

Attachment 2 – Sediment Grainsize Memo

MEMO

Report Date: October 1, 2014

To: Dave Bartus and Melissa Blankenship — U.S. Environmental Protection Agency

Rob Webb — Dalton, Olmsted & Fuglevand, Inc.

From: Robert Gilmour — AMEC

Subject: Grain-Size Data used to Estimate Percentage of Sediment Retained by the TRIFLOW During Processing of the Early Removal Area Dredge Slurry

The Lower Duwamish Waterway Feasibility Study (AECOM 2012) final sediment data base was queried for grain-size data in the vicinity of the Early Removal Areas. Surface grab samples (0-0.3 feet) and surface and shallow subsurface core segments (representing 0-1.0 foot [or less] and 1.0 to 2.0 feet) with grain-size data located within the selection box presented on Figure 1 are presented in Table 1. Sample locations that were shoreward of the Duwamish Sediment Other Area (DSOA) boundary along the pre-construction Southwest Bank shoreline were excluded from the analysis. The sediments represented by these samples were removed during the construction of the habitat project. The remaining samples were used to estimate the sediment present in the top 2 feet in the vicinity of the Early Removal Areas.

The grain-size data are presented as fractional percentages in standard phi size classes. The sum of the fractional percentages does not consistently equal 100 percent because of rounding errors, estimated values, and differences in methodology when dry sieving samples and estimating percentages in the silt/clay fractions.

The average percentage of sediment that will be retained by TRIFLOW screen required some simplifying assumptions. The final screen size used in the TRIFLOW is a No. 100 screen which has a 150-micron mesh size. The grain-size phi sizes reported in the data base whole numbers. The closest size fraction to the No. 100 screen is the phi size 2 to 3 fraction (250 microns to 125 microns). Using this size fraction as the smallest size fraction retained on the TRIFLOW screen may overestimate the percentage of the total sediment retained.

The sum of the fractional percentages for phi size 3 and coarser is divided by the total percentage of all the fractions to estimate the percentage retained by the TRIFLOW. The percentage coarser than phi 3 in each sample was averaged to estimate retention. Average

AMEC Environment & Infrastructure, Inc.
3500 188th Street SW, Suite 601
Lynnwood, Washington
98037-4763
USA
Tel (425) 921-4000
Fax (425) 921-4040
www.amec.com

retention by the TRIFLOW was estimated to be 32 percent by weight with 68 percent going on to the basin.

References

AECOM. 2012. Final Feasibility Study, Lower Duwamish Waterway, Seattle, Washington. Prepared for The Lower Duwamish Waterway Group by AECOM, for submittal to the U.S. Environmental Protection Agency, Region 10, Seattle, Washington and the Washington State Department of Ecology, Northwest Regional Office, Bellevue, Washington.

P:\BOEING\DESIGN\DATA\RBDA Support\Triflow Sediment Retention memo.docx

Attachments:
Table 1 – Grain Size Results for Sediment Samples Collected in the Vicinity of the Early Removal Areas
Figure 1 – Sample Locations With Grain Size Data in the Vicinity of the Early Removal Areas

TABLE 1

GRAIN SIZE RESULTS FOR SEDIMENT SAMPLES COLLECTED IN THE VICINITY OF THE EARLY REMOVAL AREAS

Duwamish Sediment Other Area and Southwest
Bank Corrective Measure and Habitat Project,
Boeing Plant 2, Seattle/Tukwila, Washington

Sample ID	DUW161-0000	LDW-SS109-010	LDW-SS539-010	SD2B-DUW72-0000	SD2B-DUW73-0000	SD2B-DUW89-0000	SD-307-0000	SD-316-0000	SD-321-0000	SD-DR184-0000	SD-DUW15-0000	SD-DUW16-0000	SD-DUW53-0000
Location	SD-DUW161	LDW-SS109	LDW-SS539	SD-DUW72	SD-DUW73	SD-DUW89	SD-307-S	SD-316-S	SD-321-S	DR184	SD-DUW15	SD-DUW16	SD-DUW53
Easting	1275760	1275746	1275627	1275603	1275742	1275816	1275819	1275820	1275593	1275789	1275629	1275767	1275691
Northing	195741	195745	195675	195805	195681	195705	195684	195650	195765	195644	195843	195727	195768
Sample Interval	0 - 15 cm	0 - 10 cm	0 - 10 cm	0 - 9 cm	0 - 9 cm	0 - 9 cm	0 - 10 cm	0 - 10 cm	0 - 10 cm	0 - 10 cm	0 - 9 cm	0 - 9 cm	0 - 9 cm
Grain Size Fractional Sizes													
Fractional % >9525 microns										0.01			
Fractional % Sieve 3/8-inch (4750-9525 microns)										0.01			
Fractional % Sieve #4 (>4750 microns)				2	0.01	19					0.01	0.01	0.01
Fractional % Sieve #10 (2000-4750 microns)				0.01	0.01	12					0.01	0.01	2
Fractional % phi -2-(-1) (2000-4000 microns)										0.01			
Fractional % phi >-1 (>2000 microns)		10.3	0.2				0.6	2.9	0.2				
Fractional % phi -1-0 (1000-2000 microns)	3.7	4.6	0.6	0.01	0.01	5	1.4	1.6	1	0.01	1	1	2
Fractional % phi 0-1 (500-1000 microns)	10	7	8.2	0.01	0.01	6	3.1	1.7	1	1.5	4	2	5
Fractional % phi 10+ (<0.98 micron)	3.1	4.3	2.7	6	4	1	4	5.6	10.4	6.17	1	3	1
Fractional % phi 1-2 (250-500 microns)	22.5	13.8	28.3	1	0.01	8	21.3	4.6	1.8	1.15	27	7	18
Fractional % phi 2-3 (125-250 microns)	15.5	11.3	24.7	1	1	6	21.3	6.6	6.5	1.39	24	5	28
Fractional % phi 3-4 (62.5-125 microns)	10.6	7.4	8.7	5	8	4	7.3	9.4	11.9	5.1	10	9	16
Fractional % phi 4-5 (31.2-62.5 microns)	5.2	12.3	10.8	15	25	8	10.4	18.6	13.3	20.52	12	25	7
Fractional % phi 5-6 (15.6-31.2 microns)	8.1	10.4	6	25	23	8	12.1	23	20.8	28.55	7	17	8
Fractional % phi 6-7 (7.8-15.6 microns)	6.7	7.9	4.3	21	19	7	8.7	15.2	15.7	20.07	5	12	5
Fractional % phi 7-8 (3.9-7.8 microns)	4.4	5.5	2.7	13	11	6	5.2	6	8.7	8.65	4	8	3
Fractional % phi 8-9 (1.95-3.9 microns)	2.9	3.1	1.7	6	4	3	2.9	2.7	5.2	4.24	2	5	2
Fractional % phi 9-10 (0.98-1.95 microns)	2.4	2.2	1.1	4	3	2	1.8	2.1	3.6	2.66	1	3	2
Percentage > 125 microns	58%	51%	65%	10%	5%	60%	52%	23%	21%	10%	58%	19%	57%

Sample ID	DUW153-0000	DUW154-0000	DUW155-0000	DUW156-0000	DUW157-0000	DUW158-0000	DUW159-0000	DUW160-0000	DUW162-0000	DUW163-0000	DUW164-0000	DUW165-0000	SD-201-0000
Location	SD-DUW153	SD-DUW154	SD-DUW155	SD-DUW156	SD-DUW157	SD-DUW158	SD-DUW159	SD-DUW160	SD-DUW162	SD-DUW163	SD-DUW164	SD-DUW165	SD-201
Easting	1275653	1275694	1275703	1275706	1275744	1275735	1275729	1275766	1275758	1275786	1275782	1275811	1275620
Northing	195822	195802	195794	195777	195790	195775	195755	195763	195720	195731	195705	195697	195780
Sample Interval	0 - 30 cm	0 - 30 cm	0 - 30 cm	0 - 24 cm	0 - 30 cm	0 - 30 cm	0 - 30 cm	0 - 27 cm	0 - 24 cm	0 - 21 cm	0 - 18 cm	0 - 21 cm	0 - 30 cm
Grain Size Fractional Sizes													
Fractional % phi >-1 (>2000 microns)													0.1
Fractional % phi -1-0 (1000-2000 microns)	10.7	6.9	10.5	2.3	8.6	4.9	2.4	2.8	3.2	5.1	1.9	3.2	1.1
Fractional % phi 0-1 (500-1000 microns)	14.4	11.6	13.4	2.7	10.5	6.9	7.7	2.8	2.9	15.9	3.2	6.1	1.3
Fractional % phi 1-2 (250-500 microns)	19	22.7	17.6	3.1	13.4	9.2	16.7	4.8	6.3	49.3	7	27.2	1.6
Fractional % phi 2-3 (125-250 microns)	12.5	12.6	9.6	3.9	7.9	7.1	20.3	11.5	6.1	15.7	9.2	31.4	3.5
Fractional % phi 3-4 (62.5-125 microns)	5.8	2.6	3.4	11.9	3.8	9.1	12	10.7	17.7	2.5	14.1	7	10.8
Fractional % phi 4-5 (31.2-62.5 microns)	3.1	0.6	0.4	9	3	6.3	8.4	11.7	12.4	0.7	9.8	3.5	14.9
Fractional % phi 5-6 (15.6-31.2 microns)	5.1	1.1	2.8	23.2	2.4	11.9	11.9	17.6	20.1	0.7	20.9	5.3	20.1
Fractional % phi 6-7 (7.8-15.6 microns)	4	0.6	2	17.5	2.4	8.2	9	15.1	13.1	0.6	15.7	4.2	18.1
Fractional % phi 7-8 (3.9-7.8 microns)	3.3	0.5	1.6	8	1.8	5	3.7	9.4	7.1	0.6	6.7	3.3	8.7
Fractional % phi 8-9 (1.95-3.9 microns)	2.1	0.5	1.2	4.7	1.1	2.7	1.4	4	3.1	0.3	3.4	1.8	5.9
Fractional % phi 9-10 (0.98-1.95 microns)	1.7	0.4	0.6	3	0.8	1.9	1	2.7	2.2	0.2	2.7	1.5	3.8
Fractional % phi 10+ (<0.98 micron)	1.8	0.3	0.9	6	0.9	3.2	2.1	5.9	5.6	0.8	4.8	3	10.1
Percentage > 125 microns	68%	89%	80%	13%	71%	37%	49%	22%	19%	93%	21%	70%	8%

TABLE 1

GRAIN SIZE RESULTS FOR SEDIMENT SAMPLES COLLECTED IN THE VICINITY OF THE EARLY REMOVAL AREAS

Duwamish Sediment Other Area and Southwest
Bank Corrective Measure and Habitat Project,
Boeing Plant 2, Seattle/Tukwila, Washington

Sample ID	SD-201-0010	SD-202-0000	SD-202-0010	SD-203-0000	SD-203-0010	SD-204-0000	SD-204-0010	SD-205-0000	SD-205-0010	SD-205D-0000	SD-205D-0010	SD-301-0000	SD-301-0010
Location	SD-201	SD-202	SD-202	SD-203	SD-203	SD-204	SD-204	SD-205	SD-205	SD-205D	SD-205D	SD-301	SD-301
Easting	1275620	1275659	1275659	1275714	1275714	1275755	1275755	1275767	1275767	1275772	1275772	1275659	1275659
Northing	195780	195743	195743	195744	195744	195698	195698	195648	195648	195650	195650	195767	195767
Sample Interval	30 - 61 cm	0 - 30 cm	30 - 61 cm	0 - 30 cm	30 - 61 cm	0 - 30 cm	30 - 61 cm	0 - 30 cm	30 - 61 cm	0 - 30 cm	30 - 61 cm	0 - 30 cm	30 - 61 cm
Grain Size Fractional Sizes													
Fractional % phi >-1 (>2000 microns)	0.3	0.1	0.1	2.7	0.9	0.1	0.1	0.3	1	0.1	0.1	1.1	0.1
Fractional % phi -1-0 (1000-2000 microns)	1.4	1.3	1.3	1.7	1.7	1.1	1	1.3	1	1.2	0.8	0.8	0.6
Fractional % phi 0-1 (500-1000 microns)	1.7	1.1	1.2	7.5	8	0.8	1	0.9	0.5	1	0.8	2.2	2.8
Fractional % phi 1-2 (250-500 microns)	2.1	0.9	0.7	20.8	26.3	0.6	1.3	0.8	1.1	1.5	1.5	10.2	5.1
Fractional % phi 2-3 (125-250 microns)	3	1.7	0.9	19.7	32.1	3	2.9	1.2	2.2	3.2	2.5	8.1	13.9
Fractional % phi 3-4 (62.5-125 microns)	9.2	7.8	5	10.1	14.6	11.7	12	6.3	9	7.5	9.2	11.9	20.8
Fractional % phi 4-5 (31.2-62.5 microns)	12.8	18.2	11.1	10.3	6.1	19.4	19.4	14	18.4	15	21.6	13.6	15.7
Fractional % phi 5-6 (15.6-31.2 microns)	19.8	23	30.4	12.7	4.3	25.1	24	30	40	37.1	26.5	16.1	15.4
Fractional % phi 6-7 (7.8-15.6 microns)	17.9	18.1	27.2	6.2	2.9	19.3	19.5	19.7	12.7	15.9	18.8	14.9	12
Fractional % phi 7-8 (3.9-7.8 microns)	10.7	10.1	7.9	3.7	1.6	7.2	6.7	8.5	4.8	5	6.2	6.6	3.9
Fractional % phi 8-9 (1.95-3.9 microns)	6.1	5.5	4.2	2.4	1	3.5	3.7	5.2	2.8	3.1	3.4	4.4	2.7
Fractional % phi 9-10 (0.98-1.95 microns)	4.3	3.9	2.9	1.5	0.4	2.4	2.4	2.3	2.6	1.8	2.5	2.5	1.7
Fractional % phi 10+ (<0.98 micron)	10.6	8.4	7.1	0.7	0.1	5.8	6.1	9.6	4	7.7	6.3	7.6	5.3
Percentage > 125 microns	9%	5%	4%	52%	69%	6%	6%	4%	6%	7%	6%	22%	23%

Sample ID	SD-302-0000	SD-302-0010	SD-303-0000	SD-303-0010
Location	SD-302	SD-302	SD-303	SD-303
Easting	1275724	1275724	1275762	1275762
Northing	195692	195692	195667	195667
Sample Interval	0 - 30 cm	30 - 61 cm	0 - 30 cm	30 - 61 cm
Grain Size Fractional Sizes				
Fractional % phi >-1 (>2000 microns)	0.1	0.1	0.1	0.1
Fractional % phi -1-0 (1000-2000 microns)	1	1.2	1.1	1.2
Fractional % phi 0-1 (500-1000 microns)	1	0.8	1	1
Fractional % phi 1-2 (250-500 microns)	1.6	0.8	0.9	1.7
Fractional % phi 2-3 (125-250 microns)	2.3	1.6	1.7	2.8
Fractional % phi 3-4 (62.5-125 microns)	5.9	8.8	6.8	10.9
Fractional % phi 4-5 (31.2-62.5 microns)	16.3	16.9	17.6	17.7
Fractional % phi 5-6 (15.6-31.2 microns)	29.3	24.5	27.3	26.5
Fractional % phi 6-7 (7.8-15.6 microns)	19.6	20.9	20.6	18.8
Fractional % phi 7-8 (3.9-7.8 microns)	6.8	7.6	8.1	5.9
Fractional % phi 8-9 (1.95-3.9 microns)	4.3	4.2	4.1	3.8
Fractional % phi 9-10 (0.98-1.95 microns)	2.7	3	2.3	2.3
Fractional % phi 10+ (<0.98 micron)	9	9.6	8.5	7.4
Percentage > 125 microns	6%	5%	5%	7%

Note: The percentage of sediment retained by a 125 micron mesh screen (Number 120 sieve) is calculated by adding the fractional % for Phi sizes 2 - 3 and coarser sediments divided by the sum of the fractional percentages. The sum of the fractional percentages does not alaways add up tp 100%.

Average percentage of sediment retained on a 125 micron screen	32%

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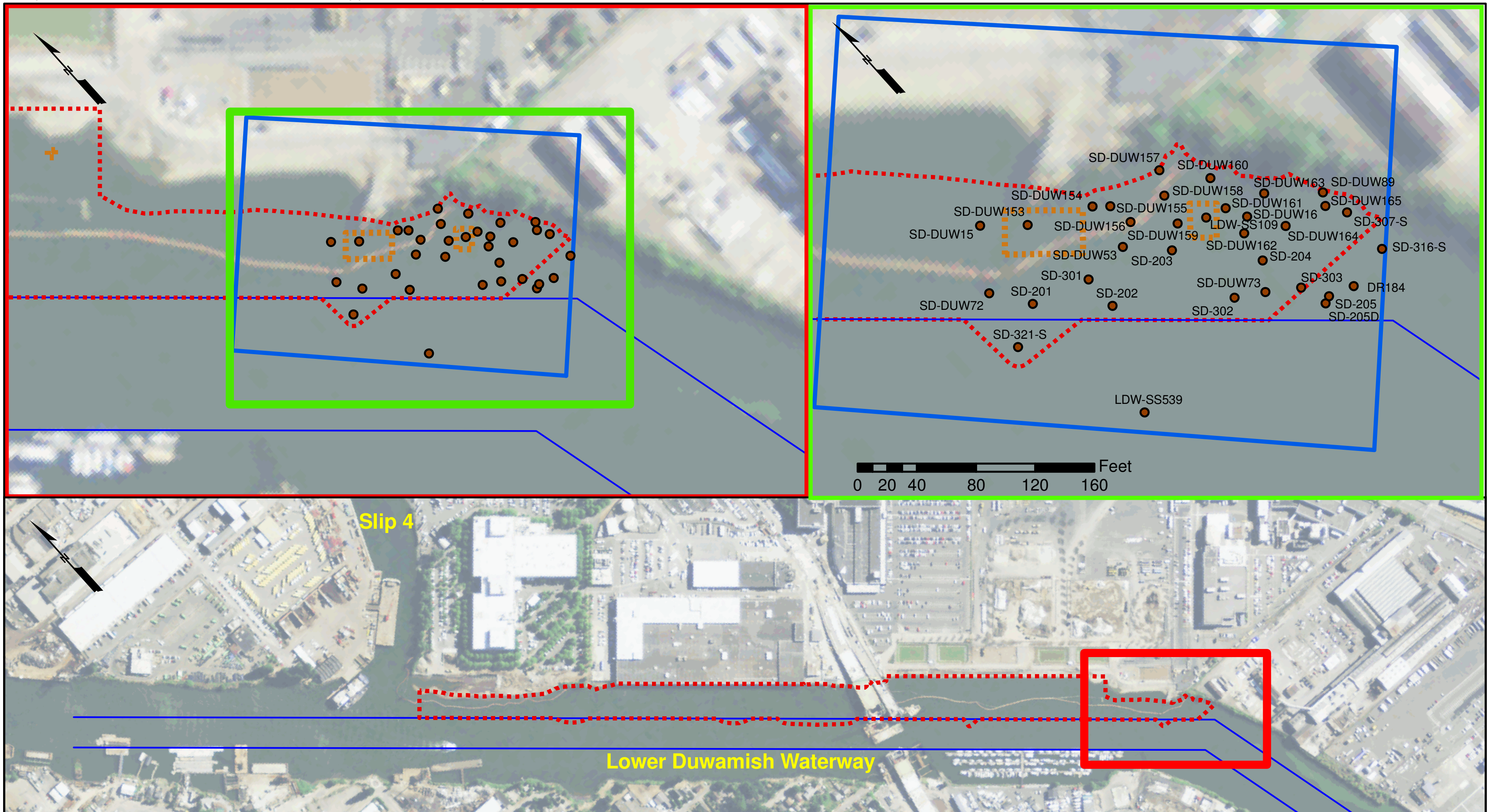

Legend

- Duwamish Sediment Other Area
- Navigation Channel Boundary
- Station Selection Box
- Early Removal Area
- Surface Sample Locations

BOEING

SAMPLES LOCATIONS WITH GRAIN SIZE DATA
IN THE VICINITY OF THE EARLY REMOVAL AREAS

Duwamish Sediment Other Area and Southwest
Bank Corrective Measure and Habitat Project,
Boeing Plant 2, Seattle/Tukwila, Washington

By: RHG	Date:9/30/2014	Project No. 0131320090
		Figure 1